Technical Attachment
Description of CN AEI Readers

As required by the FCC's Rules, 47 C.F.R. Section 90.351(a), applicable to the licensing of systems in the Location and Monitoring Service (LMS), this attachment provides the following supplemental information, denoted in bolded, underlined, typeface:

(1) **Description of operation**. Fig. 1 below illustrates the operation, which is typical of many railroad installations across the country.

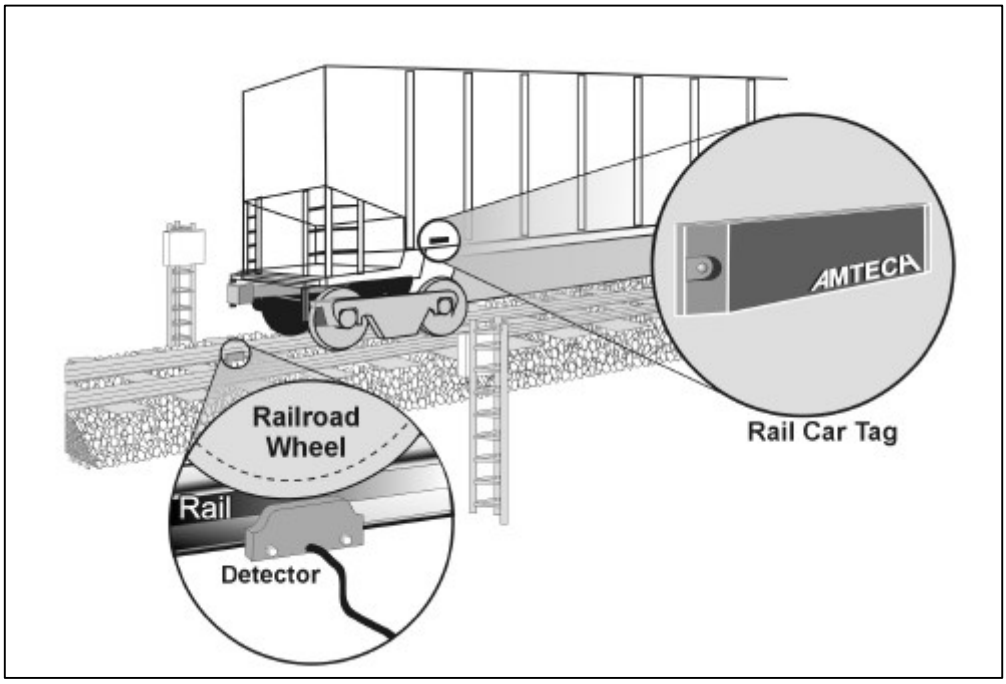

Fig. 1: Automatic Equipment Identification (AEI) track site and readers

Rolling stock tag readers are mast mounted, approximately 3.5 feet above the rail head and 10 feet either side of the track. The Automatic Equipment Identification (AEI) tags are affixed to either side of a rail car and are interrogated by the readers as the rail car traverses the track section. The tag reader system is enabled for operation by a wheel presence detector. The arming wheel presence detector is like the unit shown in the inset but placed a sufficient distance ahead of the readers. When the rail car passes the reader head the wheel detector detects the presence of the passing steel flange of the wheel and triggers the AEI reading process.

The block diagram of Fig. 2 indicates the function of each component. The RF module transmits an unmodulated signal in the direction of a tag (f_o). The tag, which is fixed to the side of rail car traversing the site, reflects a modulated signal back to the RF module

(f_{om}). The RF module receives the reflected signal from the tag and relays this information to the reader. The reader decodes the information contained in the tag and relays the information to a host computer for subsequent use to identify, track, and schedule the tagged rail car.

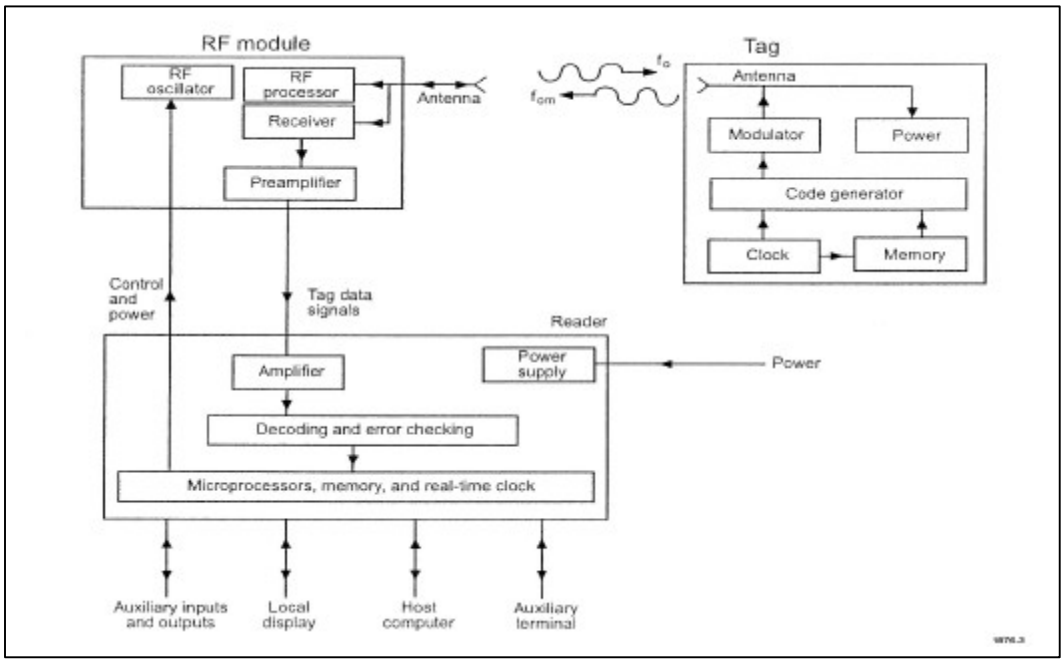

Fig. 2: Block diagram of the RF module, reader, antenna and tag

(2) The **occupied bandwidth** of emission is 20KHz and the designator used for associated applications is 20K0N0N.

(3) The **data transmission characteristics** are as follows:
(i) The vehicle location **update rates** are directly proportional to the number of train passings and density of AEI system installations along the railroad right-of-way. A train passing can be anticipated approximately every 20 minutes.
(ii) **Specific modulation techniques**:
The AEI tag on the rail car acts as a field disturbance device, only modifying and reflecting the signal transmitted by the reader system. The slight modification of the signal includes the unique identification code of the tag. This method of communication is called "modulation back scatter."
(iii) **Coding and timing schemes** are described below:

TAG DATA FORMAT FOR THE RAILCAR
Revenue and Non-Revenue Freight and Passenger Equipment,
Except Rail-Compatible Multi-Modal Equipment -- See Appendix M

1.0 Bits Available for General Use

Fields specified by the Standard are listed in Table A; General Use fields are indicated in **bold** type. A description of each General Use field is presented in the paragraphs following Table A.

Table A: Data Field Descriptions for the Railcar Tag

Entry	Bits Required Unit	Tag Data Sequence	Minimum Value	Maximum Value	
Equipment Group Code	**5**	**0-4**	**0**	**3**	**Type Code**
Tag Type	**2**	**5-6**	**1**	**4**	**Type Code**
Equipment Initial (Mark)	**19**	**7-25**	**A**	**ZZZZ**	**Alpha**
Car Number	**20**	**26-45**	**0**	**999999**	**Numeric**
Side Indicator Code	**1**	**46**	**0**	**1**	**Side Code**
Length	**12**	**94-96,**	**0**	**4095**	**Decimeters**
		47-55*	**[0**	**1343**	**Feet]**
Number of Axles	**5**	**56-59,64**	**1**	**32**	**Axles**
First Check Sum	2	60-61			
Reserved Frame Marker	2	62-63			
Bearing Type Code	**3**	**65-67**	**0**	**7**	**Type Code**
Platform Identifier Code	**4**	**68-71**	**0**	**15**	**Platform Code**
Spare	**2**	**72-96**			**Available for Owner Use**
Reserved	9	97-105			For Future AARUse
Security	12	106-117			Reserved for Security or Limited Owner's Use
Data Format Code	6	118-123			
Second Check Sum	2	124-125			
Frame Marker	2	126-127			

* Bit order shall be 94, 95, 96, 47, 48 ... 55.

The fields are arranged in a hierarchical fashion in order to expedite processing by the data processor. It is intended that the data processor will first look at the Data Format Code to determine if the tag should be ignored. For example, in some cases the data processor will wish to ignore all tags except those specified as rail (AAR Standard) or intermodal tags.

Once the Data Format Code has been processed, then the data processor will look to the Tag Type to determine the configuration, capabilities, and memory capacity of the

tag. Next, the data processor will examine the Equipment Group Code to determine if the tagged equipment is relevant.

The order in which the remaining fields are processed will be dictated by the particular application.

1.1 Equipment Group Code

This is a numeric field having a value from 0 to 31 that indicates the general type of equipment. The Equipment Group Code for freight and passenger railcars is decimal 19 (binary 10011).

1.2 Tag Type

The Tag Type indicates the configuration, capability, and memory size of the tag. Tag Type = 2 describes this tag specified by this AAR Standard.

To code the Tag Type value into the tag, the decimal value is reduced by one and converted to its base 2 equivalent.

1.3 Equipment Initial (Reference UMLER Columns 3 - 6)

The Equipment Initial is composed of four (4) letters and can be represented as C1; C2; C3; C4. To code this information in the tag, the possible letters represented by C1 will be assigned to the following decimal values: A = 0, B = 1, C = 2, ... Z = 25. The letters C2, C3 and C4 will be assigned the following values: Blank = 0, A = 1, B = 2, ... Z = 26. This code assignment allows for an Initial of less than four characters, with the actual characters left justified, and the remainder of the field padded with blanks.

Conversion from alpha to numeric would involve the following:

1. Determine the numeric equivalent of characters C1 through C4. This will result in four numeric values; N1 through N4.

2. Convert N1 through N4 into one numeric value by using the formula:
   $Value = (N1x27^3) + (N2x27^2) + (N3x27) + N4$

The base 2 equivalent of the decimal number "Value" is stored in the tag's Equipment Initial field. Conversion from a base 2 tag format back to the four letters would involve the following, where "Value" is the decimal equivalent of the base 2 value in the Equipment Initial field.

1. $N1 = Value/27^3$ (integer - drop fractions)

2. $N2 = (Value - (N1x27^3))/27^2$ (integer)

3. $N3 = (Value - ((N1x27^3) + (N2x27^2)))/27$ (integer)

4. $N4 = Value - ((N1x27^3) + (N2x27^2) + (N3x27))$

5. Use the letter-to-number assignments referred to above to convert N1 through N4 from a numeric value to its letter equivalent.

1.4 Car Number

The Car Number is encoded into the tag by converting the decimal value from 0 to 999999 to a binary value (a conversion from base 10 to base 2).

1.5 Side Indicator Code

The Side Indicator Code indicates whether the tag is installed on the left or right side of a railcar. The right or left side is in reference to a person facing the car from the handbrake end (B end) of the car (see diagram, Exhibit A). The right side of the car is assigned a binary value 1 and left side of the car is assigned a binary value 0.

1.6 Length (Reference UMLER Line 2, Columns 20 - 24)

The exterior length is measured as specified by the UMLER Data Specification Manual. To encode the data into the tag, the metric value from 0 to 4095 decimeters is converted to a base 2 equivalent value.

1.7 Number of Axles (Reference UMLER Line 3, Column 50)

This field indicates the number of axles on a car. To encode the Number of Axles into the tag, the decimal value from 1 to 32 is reduced by one and converted to base 2.

1.8 Bearing Type Code (Reference UMLER Line 3, Column 49)

To encode the Bearing Type Code into the tag, the decimal value of 0 through 7 must be converted to the equivalent base 2 value. Table B presents a description of each Bearing Type Code value.

Table B: Data Values for the Bearing Type Code

Value	Description
0	Plain Bearings
1	Roller Bearings, Not Otherwise Classified
2	Roller Bearings, Inboard
3	Roller Bearings, 3 Axle Truck, 1 Axle Obstructed ("Buckeye Design")
4	Roller Bearings, Plain Bearing Housing
5	Roller Bearings, Cylindrical Oil Filled
6-7	Reserved

1.9 Platform Identifier Code (Reference UMLER Line 4, Column 35)

Table C presents the values assigned to each platform identifier code. Non-articulated or single unit cars shall be assigned the value 0. All equipment except articulated rail cars shall be assigned the value 0. For multi-unit cars, "B" is assigned to the platform stenciled "B" and A is assigned to the extreme opposite platform. Platforms adjacent to the "B" platform are assigned "C", "D", "E", etc. in a sequential manner for consecutive platforms moving away from the "B" platform. To encode the Platform Identifier Code into the tag, the decimal value from 0 to 15 must be converted to its equivalent base 2 value.

Table C: Data Values for the Platform Identifier Code

Value	Description
0	All Equipment, Except Articulated Railcars (Includes Single Platform and Non-Articulated Cars)
1	"A" Platform
2	"B" Platform
3	"C" Platform
4	"D" Platform
5	"E" Platform
6	"F" Platform
7	"G" Platform
8	"H" Platform
9	"I" Platform
10	"J" Platform
11	"K" Platform
12	"L" Platform
13	"M" Platform
14	"N" Platform
15	"O" Platform -- Also applies for platforms beyond the 15th

(iv) The **message interrogation format** includes the encoding of 8 sub-bits for each user bit. A sub-bit shall be coded by the tag and decoded by the sensing equipment with a modified FSK (frequency shift keying) code using two harmonically related frequencies, one (40 kHz) being the exact multiple of the other (20 kHz), with a frequency tolerance of ±10%. A '0' bit shall consist of one 20 kHz square wave cycle followed by two 40 kHz square wave cycles. A '1' bit shall consist of two 40 kHz square wave cycles followed by a 20 kHz square wave cycle. All transitions shall be phase-continuous. As depicted in Fig. 3, the tag will produce a waveform with a nominal 1 microsecond rise and fall time and duty cycle for the 20 and 40 kHz square wave cycles of 50%.

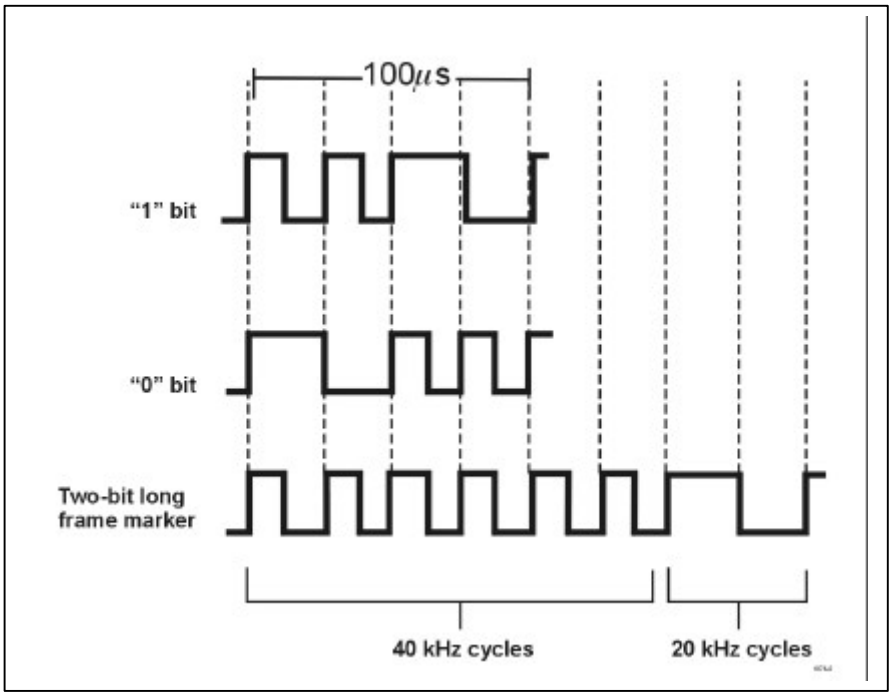

Fig. 3: Frequency – shift keying (FSK) encoding

The tag electronics will cause the data to scroll repeatedly without pause from bit "cell" 127 of a frame (a frame consisting of all 128 bits) to bit "cell" 0 of the succeeding frame.

Battery and non-battery powered tags are offered in the AEI service where battery operated units require a minimum field strength of 2.0 v/m and operate reliably with greater that 3.5 v/m. Battery operated units have a much greater sensitivity on the order of 750 mV/m and some go as low as 150 mV/m. Battery-powered dynamic tags shall be operational within 7 ms of excitation by an interrogating signal from sensing equipment. All other tags shall be operational within 4 ms of excitation by an interrogating signal from sensing equipment.

(4) **The implementation schedule** of this station is complete, as discussed in the attached "Description of Filing."